

# **COST-BENEFIT ANALYSIS OF THE OVERHEAD CEILING LIFTS IN REDUCING MUSCULOSKELETAL INJURY AMONG DIRECT PATIENT CARE STAFF**

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## **ABSTRACT**

Patient and/or resident handling is a major cause of injury to healthcare workers. Ceiling lifts are frequently advocated to mitigate risk of injury to healthcare workers when lifting, transferring, or repositioning patients.

A longitudinal study was conducted in three extended care facilities to evaluate the efficacy and cost-benefit of overhead lifts in reducing the risk of musculoskeletal injury (MSI) among direct patient care staff.

Analysis of injury trends spanning 6 years pre-intervention (1996-2001) and 4 years post-intervention (2002-2005), found a significant and sustained decrease in workers' compensation claims per number of bed and days lost per bed. The payback period was estimated under various assumptions and varied from 6.3 to 6.2 years if only direct claim cost savings were included and from 2.06 to 3.20 years when indirect savings were also included.

The rapid economic gains and sustained reduction in the frequency and cost of patient handling injuries strongly advocate for ceiling lift programs as an intervention strategy.

## **INTRODUCTION**

There is a high prevalence of musculoskeletal injury (MSI) among health care workers (HCWs).<sup>1-7</sup> HCWs who regularly lift/transfer/reposition patients are at a greater risk of injury than those who do not.<sup>3,8-9</sup> Biomechanical analysis of spinal compressive and shear forces,<sup>10-14</sup> and HCW perceptions<sup>15-17</sup> suggest that manual lifting, transferring and repositioning tasks are particularly high-risk activities. The combination of high MSI incidence and prevalence associated with patient handling and the corresponding high estimates of biomechanical stress during manual handling procedures have spurred extensive efforts to develop safer methods for moving patients.

Mechanical devices such as floor lifts have frequently been advocated to assist in moving patients. However, these lifts are often not used to the full extent due to poor access, lack of space for use or storage, difficulty in operating, inadequate staffing, or increased time required for use of the lift compared to manual methods.<sup>10,18-20</sup> In recent years, overhead lifting devices have been endorsed as a replacement for mechanical floor lifts to overcome most of the usage problems.<sup>21-24</sup> Ceiling lifts utilize a ceiling mounted track, electric motor, and a sling to provide mechanical assistance for lifting, transferring, and repositioning patients. A single lift may be configured to support handling of patients for one or more beds. Since ceiling lifts are mounted overhead, they are easier to store and require less room to operate than floor lifts, and have been more effective at reducing the risk of injury associated with patient handling.<sup>14,22</sup> This style of lift requires minimal physical effort to manoeuvre, and offers the added feature of always being accessible for use in patient care areas. Holliday et al. (1994)<sup>21</sup> reported significant time-savings when ceiling lifts were used for lifting and transferring patients. Additionally, Zhuang et al. (1999)<sup>14</sup> found that using ceiling lifts to transfer patients from bed to chair eliminated approximately two-thirds of the exposure to low-back stress, when compared to manual methods.

A Memorandum of Understanding (MOU) was signed by the Healthcare Employers and Unions in British Columbia in March 2001 to eliminate unsafe manual handling of patients in BC healthcare facilities.<sup>25-26</sup> The MOU states that ‘the parties agree to establish a goal of eliminating all unsafe manual lifts of patient through the use of mechanical equipment, except where the use of mechanical lifting equipment would be a risk to the well-being of the patients’ To reduce the number of patient handling MSIs, Providence Health Care (a large health care provider in Vancouver) in cooperation with WorkSafeBC and the Ministry of Health, has been installing and using overhead ceiling lifts in its facilities since 2001.

The specific objectives of this research are to: 1) assess the frequency, rate and days lost for resident handling injuries over a ten-year period before and after ceiling lifts were installed; and 2) evaluate the costs and benefits of the ceiling lift intervention program.

## **METHODS**

Three extended care facilities of Providence health care were chosen for this analysis: Langara, Brock Fahrni, and Youville Residence. Langara is a home of 221 long-term care residents. Brock Fahrni provides care to 150 extended care residents, many of whom are armed forces veterans. Youville Residence is a multi-level care facility for 84 residents. Starting in 2002, ceiling lifts were installed in these facilities. By the end of 2005, a total of \$1,081,410 was spent to procure and install 110 lifts in these three facilities. Associated training and maintenance costs were included with this price tag.

### **Data collection and analysis**

Data for Brock Fahrni, Langara and Youville were obtained through Parklane-an injury incident tracking system used by Providence. All MSIs among direct care staff related to patient care claims for these facilities were extracted from the Parklane system. MSI claims, claims costs, and days lost were obtained spanning a period of 10 years. The study was divided into pre-intervention (1996-2001) and post intervention (2002-2005) periods. Since ceiling lifts were installed in this facility from 2002, it was expected that there would be impacts on patient

handling related MSI rates, claim costs, and days lost associated with these MSI starting from 2002. For the purposes of this evaluation, it was assumed that all lifts (110 in total) at this facility were installed in 2002.

“Claims” were defined as injuries accepted for compensation by WorkSafeBC. To calculate MSI rates, the number of beds was used as denominator. The data on number of beds at the 3 facilities was collected for the entire study period. It was assumed that the workload (e.g., direct care staff to bed and direct care staff to patient handled ratios) remained unchanged over the 10-year study period. The number of MSI claims, claims costs, and days lost per beds were calculated for each year. Poisson regression models were applied to monitor the trends and to evaluate the influence of the ceiling lift project on altering any pre-intervention trend.

Claims costs were adjusted for inflation. Using the Provincial consumer price index <sup>[Statistics, Canada]</sup> the costs were adjusted to 2005 Canadian dollar. All these values were then discounted by 3% to take into account the differential time value of money <sup>[Drummond]</sup>.

The cost–benefit analysis was conducted by two methods. The first method assumes that the MSI rate in the year prior to intervention (2001) was representative of how the MSI rate would have continued in the absence of intervention; therefore, post-intervention savings were estimated with reference to the pre-intervention MSI rate (2001). The second method assumes that the average MSI rate for the pre-intervention period (1996-2001) would have continued through the post-intervention period in the absence of intervention; therefore, post-intervention savings were calculated relative to this rate. In both cases, the difference between actual and predicted MSIs for a year was assumed to be associated with the ceiling lift intervention. The average claim cost for an MSI was used to calculate the savings for that year.

For both methods, cost benefit was calculated with and without indirect savings associated with an MSI. Indirect savings were estimated to be equal or double that of direct savings <sup>26,28</sup> and include benefits such as less overtime, reduced employee turnover, reduced sick time, reductions in recruiting and training costs, and increased employee morale.<sup>29</sup> The payback period to recover expenditures associated with the program was estimated under these various assumptions. The average cost savings per year was divided into the total cost of the intervention to determine the payback period for the investment in ceiling lifts.

## RESULTS

### ***1. MSI claims, claim costs and days lost***

Data on patient handling related MSIs, adjusted claims costs and days lost among all direct care staff at the three facilities are presented in Table 1. Claim costs/MSI, MSI/bed, claim cost/bed, and days lost/bed were calculated and presented in Table 1.

### ***2. Trend analysis***

Table 2a presents relative risk of MSIs per bed and days lost per bed for 1997 to 2005 holding 1996 as reference. The relative risk showed a gradual decline over the study period (statistically significant for some years). The tests for trends for MSIs per bed and days lost per bed for the study period also showed statistically significant downward trends.

A second set of analysis divided the study period into pre and post ceiling lifts and calculated relative risk for both periods. There was statistically significant lowering of relative risk for both MSIs per bed and days lost per bed in the post ceiling lift period compared to the pre period (Table 2b).

**Table 1: MSI claims, claim costs and days lost**

Year	MSI	Claims costs	Adjusted Costs* in 2005 \$	days lost	Number of Beds	Cost/MSI claim	MSI/bed	Cost/bed	Days lost/bed
1996	82	\$501,766	753,302	3,193	433	\$9,186.61	0.19	\$1,739.73	7.37
1997	76	\$133,391	193,007	1,769	433	\$2,539.57	0.18	\$445.74	4.09
1998	75	\$441,503	618,512	3,339	433	\$8,246.83	0.17	\$1,428.43	7.71
1999	64	\$254,969	343,043	2,421	433	\$5,360.05	0.15	\$792.25	5.59
2000	64	\$249,036	319,282	2,287	433	\$4,988.77	0.15	\$737.37	5.28
2001	61	\$258,086	315,941	1,759	433	\$5,179.36	0.14	\$729.66	4.06
2002	47	\$132,942	154,394	957	433	\$3,284.98	0.11	\$356.57	2.21
2003	40	\$125,583	138,653	1,067	455	\$3,466.31	0.09	\$304.73	2.35
2004	39	\$270,760	284,553	2,402	455	\$7,296.22	0.09	\$625.39	5.28
2005	38	\$294,877	294,877	2,889	455	\$7,759.92	0.08	\$648.08	6.35
10 year total	586	\$2,662,913	3,415,563	22,083	4,396	\$5,828.61	0.13	777	5.02
Pre-Period total	422	\$1,838,751	\$2,543,087	14,768	2,598	\$6,026.27	0.16	\$978.86	5.68
Post-Period total	164	\$824,162	\$872,477	7,315	1,798	\$5,319.98	0.09	\$485.25	4.07

Please note: Shaded rows indicate years after the installation of ceiling lifts. Using BC's actual consumer price index and 3% discount rate

• **Table 2a: Relative risk of MSI/bed and days lost/bed**

Year	Relative risk for MSIs per bed (95% CIs)	p-values	Relative Risk for days lost per bed (95% CIs)	p-values
1996	1.00 (ref.)		1.00 (ref.)	
1997	0.93 (0.68, 1.27)	0.6332	0.55 (0.52, 0.59)	<0.0001
1998	0.91 (0.67, 1.25)	0.5765	1.05 (0.10, 1.10)	0.0709
1999	0.78 (0.56, 1.08)	0.1373	0.76 (0.72, 0.80)	<0.0001
2000	0.78 (0.56, 1.08)	0.1373	0.72 (0.68, 0.76)	<0.0001
2001	0.74 (0.53, 1.04)	0.0802	0.55 (0.52, 0.58)	<0.0001
2002	0.57 (0.40, 0.82)	0.0023	0.30 (0.28, 0.32)	<0.0001
2003	0.46 (0.32, 0.68)	<0.0001	0.32 (0.30, 0.34)	<0.0001
2004	0.45 (0.31, 0.66)	<0.0001	0.72 (0.68, 0.75)	<0.0001
2005	0.44 (0.30, 0.65)	<0.0001	0.86 (0.82, 0.91)	<0.0001
Test for trend estimate = -0.0983 95% CIs = -0.1270, -0.0696 p < 0.0001			Test for trend estimate = -0.0461 95% CIs = -0.0507, -0.0415 p < 0.0001	

**Table 2b: Pre and post trend analysis for MSI/bed and days lost/bed**

Period	Relative Risk for MSIs per bed (95% CIs)	p-values	Relative Risk for days lost per bed (95% CIs)	p-values
1996 - 2001	1.00 (ref.)		1.00 (ref.)	
2002 - 2005	0.56 (0.47, 0.67)	<0.0001	0.72 (0.70, 0.74)	<0.0001

**3. Cost Benefit Analysis**

There were 586 MSI claims during the 10-year period resulting in claims costs of \$3,415,563. The average cost of an MSI related claim was \$5,828.61. Thus, any intervention that can reduce one MSI incidence would save this amount in direct claims costs. If indirect costs (hiring, retraining, high turnover, staff satisfaction, productivity, etc.) were included, the total savings would be approximately \$11,657.21 or \$17,485.82 depending on if the indirect savings is assumed equal or double of direct savings.

Method 1 of cost-benefit analysis took the overall rate of MSI/bed for 1996-2001 as the comparative rate for pre-ceiling lift period. This rate was 0.16 MSI/bed. The difference between actual rates and this rate was calculated for each year (2002-2005) and the number of MSI prevented was calculated (Table 3). These numbers of MSI were multiplied with the average MSI claim costs for that year to calculate direct savings for 455 beds. The average savings per year were calculated for the post-intervention period with different assumption of the indirect savings. (Table 3).

The cost for intervention was \$1,081,410, which resulted in a payback period of 6.18 years with only direct savings. Including indirect savings (equal or double that of direct savings), this payback period was estimated at 3.09 years or 2.06 years (Figure 1).

**Table 3: Cost\* benefit analysis**

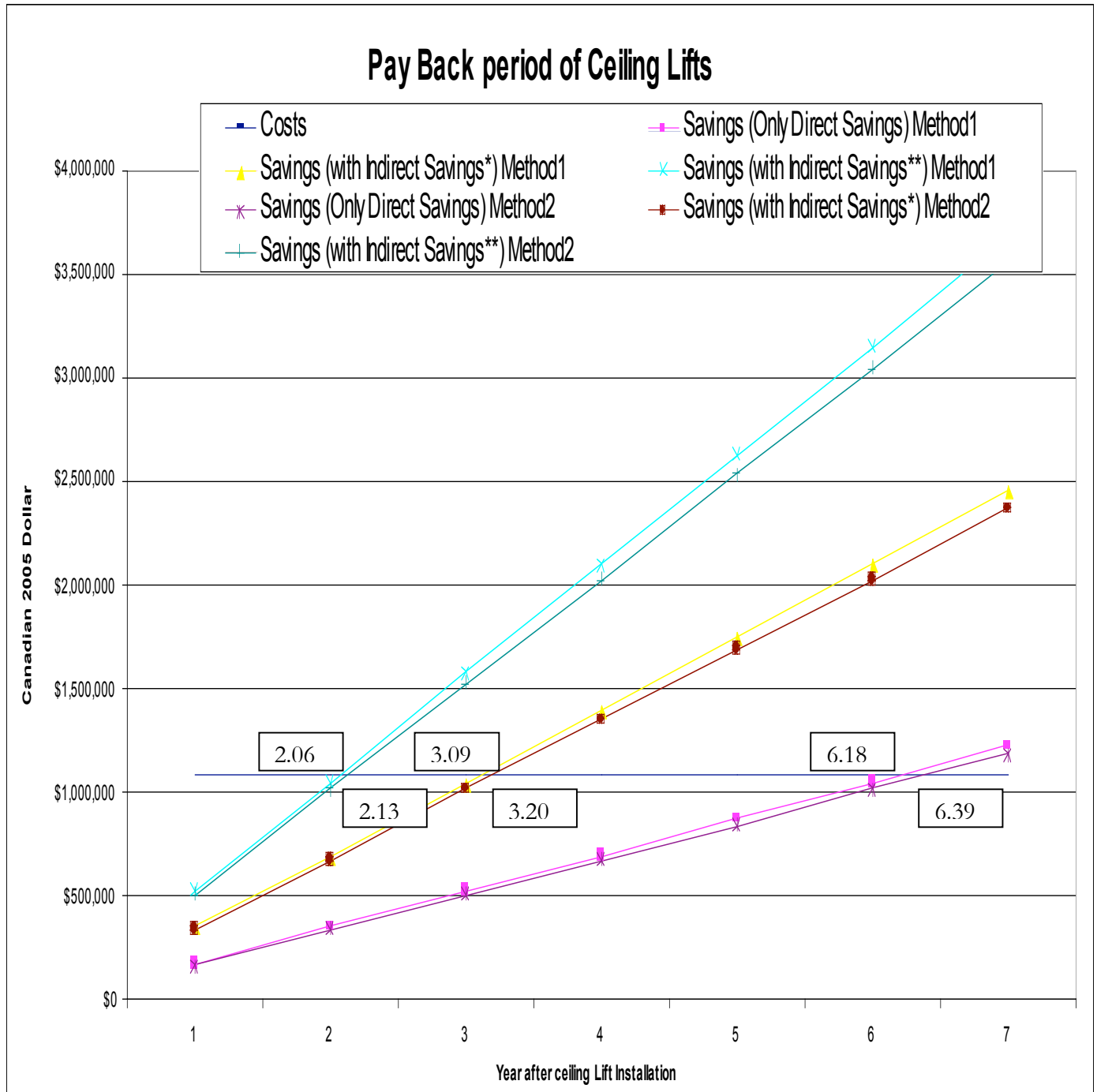
Method 1 Assuming Pre intervention rate= 0.16 (average of pre period)							
Year	Actual MSI rate (From Table 1)	Reduction in MSI rate	Average Cost of MSI claim (From Table 1)	MSI prevented (for 455 beds)	Savings (Only direct costs) (using average MSI costs)	Savings (Indirect Savings Equal direct savings)	Savings (Indirect Savings Twice of Direct savings)
2002	0.11	0.05	\$3,284.98	22.75	\$74,733.35	\$149,466.70	\$224,200.05
2003	0.09	0.07	\$3,466.31	31.85	\$110,402.13	\$220,804.26	\$331,206.39
2004	0.09	0.07	\$7,296.22	31.85	\$232,384.70	\$464,769.40	\$697,154.10
2005	0.08	0.08	\$7,759.92	36.4	\$282,461.13	\$564,922.26	\$847,383.39
Average Savings/year					\$174,995.33	\$1,399,962.62	\$2,099,943.93

<b>Method 2</b> Assuming intervention Pre rate= 0.14 (immediate past year)							
Year	Actual MSI rate (From Table 1)	Reduction in MSI rate	Average Cost of MSI claim (From Table 1)	MSI prevented (for 455 beds)	Savings (Only direct costs) (using average MSI costs)	Savings (Indirect Savings Equal direct savings)	Savings (Indirect Savings Twice of Direct savings)
2002	0.11	0.03	\$3,284.98	13.65	\$44,840.01	\$89,680.02	\$134,520.03
2003	0.09	0.05	\$3,466.31	22.75	\$78,858.66	\$157,717.32	\$236,575.98
2004	0.09	0.05	\$7,296.22	22.75	\$165,989.07	\$331,978.14	\$497,967.21
2005	0.08	0.06	\$7,759.92	27.3	\$211,845.84	\$423,691.68	\$635,537.52
Average Savings/year					\$169,132.23	\$1,003,067.16	\$1,504,600.74

\*Costs in 2005 Canadian Dollars

Method 2 of cost-benefit analysis took MSI/bed rate for 2001 (immediately before ceiling lifts were installed) as the rate for pre-ceiling lift period. This rate was 0.14 MSI/bed. The difference between actual rates and this rate was calculated for each year (2002-2005), and the number of MSI prevented was multiplied with the average MSI claim costs for that year to calculate direct savings for 455 beds (Table 3b). The average savings per year were calculated.

The cost for intervention was \$1,081,410 resulting in a payback period of 6.39 years with only direct savings. Including indirect savings, this payback period is found to be 3.2 years and 2.13 years (Figure 1).



**Figure 1: Pay Back period of Ceiling Lifts**

Method 1 Assuming pre intervention rate= 0.16 (average of pre period)

Method 2 Assuming pre intervention rate= 0.14 (immediate past year)

\*Savings (Indirect Savings Equal direct savings)

\*\*Savings (Indirect Savings Twice of Direct savings)

## DISCUSSION

The current investigation provides evidence to suggest that overhead lifting devices are effective in reducing the risk of MSI to patient care staff, and that the savings of this type of intervention outweigh the associated costs. The payback period advocates for the continued use of ceiling lifts as an intervention intended to mitigate occupational injuries related to patient handling. The payback period of the ceiling lift intervention is related to the magnitude and trends of the pre-intervention injury rate; therefore, due consideration to the MSI rate of patient handling in a given facility is important when assessing the potential economic benefits of ceiling lift interventions.

OHSAH has previously evaluated the effectiveness of ceiling lifts in reducing the risk of MSI to care staff when handling patients. Ronald et al. (2002)<sup>22</sup> evaluated the effectiveness of a ceiling lift program one year after implementation in an extended care facility in Vancouver Island. Implementing a ceiling lift program significantly reduced (58% reduction,  $p = 0.011$ ) the rate of MSI to nurses and care aides caused by lifting and transferring. Spiegel et al. (2002) evaluated the benefit and cost-effectiveness of ceiling lifts in a 65-bed extended care unit of a tertiary hospital. The study found a decrease in the number of lift and transfer injuries, with compensation costs reduced by 69% for lift and transfer injuries, and 42% for total MSIs. These figures resulted in an estimated payback period of 4 years. A longitudinal case-study by Chhokar et al. (2005)<sup>30</sup> evaluated the efficacy of overhead lifts in the same extended care unit. Analysis of injury trends, spanning 3 years pre-intervention and 3 years post-intervention, found a significant and sustained decrease in days lost, workers' compensation claims, and direct costs associated with patient handling injuries. The payback period was estimated in two ways: first by assuming that pre-intervention injury costs would continue to increase, thereby making the payback period 0.82 year; and secondly, by assuming the injury costs would plateau in the year immediately preceding intervention, thus making a 2.50 year payback period. Miller et al (2006) in a pre-post intervention study assessed the effectiveness of portable ceiling lifts in a new multi-level care facility on risk of patient handling injuries. Results indicated that staff perceived they were at significantly less risk of injury when using ceiling lifts compared to manual methods. Seventy-five percent of staff preferred to use the ceiling lifts over any other method for lifting and transferring residents. Compensation costs due to patient handling decreased in the intervention facility, with a 241% increase in the comparison facility.

Several factors that were not considered in the present study may have influenced claims rates during this period, including: changes in staffing ratios, job stress, and regional changes in compensation legislation. It is also likely that changes in the claims rates and costs may have been influenced by external factors such as criteria for claims acceptance, worker's attitudes towards filing claims, or rehabilitation practices. An increase in awareness of MSI among employers and employees may have contributed to the pre-and post intervention trends. It is difficult to differentiate between the effects of overhead lifting devices and the effects of the overall MSI prevention programs available at the facilities. The results of this project might reflect the combined influence of improved availability to mechanical lifts as well as training and changes in the awareness of best practices.

There were some other limitations to this study that should be kept in mind in its interpretations. The absence of a control group in such research design makes it difficult to ascertain the direct influence of the overhead lifting devices on reducing number of claims, compensation costs, and days lost. Extrapolating the pre-intervention MSI rate to the post-intervention period held the assumption that the observed trend would continue in the absence of lifting devices.

The claims cost values presented here were adjusted for inflation and time value of money. But, this study did not attempt to quantify the indirect costs associated with MSI, rather, it depended on published estimates that indirect savings were approximately equal or double of direct savings.

Staff perceptions on the program's effectiveness were not elicited in this study. Anecdotal evidence indicates that the staffs are satisfied with this intervention. Similarly, patient/resident feedback was not collected and their perspective regarding changes in transfer practice is not addressed in this study.

There are other methodological limitations. This study had small number of incidents to investigate, which might restrict making meaningful generalizations of the findings over other health care settings or the whole health authority. The MSI incidents captured for this preliminary analysis might not also be representative of the true risk the patient care staff experience while patient handling. Incident data for all direct care staff and for all kinds of patient handling were used as the appropriate data were lacking or not accessible. Ideally, claims should only be included if a description of the incident indicates that the use of a ceiling lift could have prevented the injury. Also, a more thorough and valid evaluation should take more years of post-intervention data into account. This analysis took a simplistic view that all lifts were installed at a time and the impact is immediate. The effectiveness of the ceiling lifts was underestimated because it was assumed that all lifts were in operation since 2002, whereas, some had been installed later and therefore had a shorter time span to have impacts on injury rates.

The aging workforce and residents and more vulnerable resident population requiring more frequent lifting/transferring and repositioning and complex care should have been associated with a higher risk of MSI incidents in the later years. These confounders were not taken into consideration and the effectiveness of the lifts was likely underestimated.

Future studies should ideally use controlled design to evaluate the effectiveness of ceiling lifts in reducing the risk of MSI to care staff and increase in staff satisfaction, and assess preferred methods of handling by the residents. Using a control facility without ceiling lifts installed would clearly discern the added effectiveness of ceiling lifts in the intervention facilities. Using a control group would require that the comparability of patient and staff mix is established first.

Further investigation is required to determine the value of ceiling lifts in different resident handling situations, such as transferring, lifting and repositioning. Future studies should also focus on the effects and cost benefits of ceiling lifts for longer term. While the results of this research are promising, more rigorous research is warranted to ascertain the long-term impact of ceiling lifts and discern its effectiveness appropriately.

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